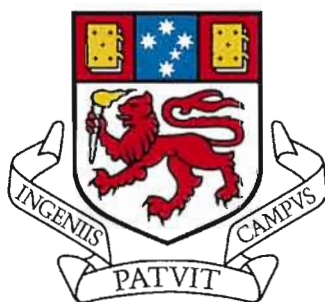


A Geophysical Investigation of the Derwent Estuary

David J Gibbons

B. Sc.



UNIVERSITY OF TASMANIA

A research thesis submitted in partial fulfillment of the
requirements of the Degree of Bachelor of Science with
Honours

School of Earth Sciences, University of Tasmania

November, 2001

Acknowledgements

Michael Roach, my supervisor and chief guru for your assistance, expertise and support (even if you did reckon the funny bits in the seismic were basalt!). Thanks especially for scraping together the funds for the project after the grant application got rejected. I hope you enjoyed your holiday, you certainly deserved it.

James Reid - stand-in guru and all-around good guy - for your help and good humour, particularly in Michael's absence. Thanks also for your lessons in the dark art - fortran 77.

Alan Jordan and Miles Lawler from the Tasmanian Aquaculture and Fisheries Institute, without whom this project could not have proceeded. Alan for providing 'mates rates' for the vessels and Miles for piloting them back and forth, back and forth, back and forth....thank you both.

David Mitchell from the University of Sydney, for his willingness to come to Hobart in the colder months (straight from the North West Shelf!) to conduct our seismic survey. His good humour and patience with my clumsiness ("Please don't stand on the eel, Dave!") certainly made the seismic survey a more pleasant experience than it might otherwise have been.

Pat Quilty for his willingness to help whenever required (particularly in terms of my literature review). Thanks also to Peter Harris, for looking at my seismic data early in the year and allowing me to use his carbonate distribution map in my thesis.

Mineral Resources Tasmania for their support both personally (through a State Government Mining Scholarship) and for their support of the project. Thanks particularly to the staff who attended and gave input at the mid-year thinktank, aka 'Roachy's presentation' ("Hi Roachy, we've come for your presentation"). Thanks also to Dr. David Leaman for his attendance and input at 'Roachy's presentation', and for other valuable discussions throughout the year.

The library staff at the SciTech and Morris Miller libraries here at Uni, the Mineral Resources Tasmania library at Rosny, and the CSIRO Marine library at Salamanca.

Cheers to my fellow honours students and any staff member or undergrad that said anything nice about me or helped me during the year. Special thanks to those who offered to review my chapters in the absence of Michael and James during the latter part of the year - Ben Jones, Luisa D'Andrea, Nolene Dorn, Geoff Peters and my brother Geoff Gibbons. Perhaps I should have taken up the offers! Special thanks also to Jodie Cutler and her friend George for their help with my fieldwork.

Thanks,

Dave.

Table of Contents

ABSTRACT	I
ACKNOWLEDGEMENTS	II
LIST OF FIGURES	V
LIST OF TABLES	VIII
CHAPTER 1 INTRODUCTION	1
THE DERWENT RIVER	1
AIMS	4
TECHNIQUES (FOR MARINE SURVEYS)	5
POTENTIAL FIELD METHODS	5
ELECTRICAL AND E/M	5
SEISMIC	6
SONAR	6
CHAPTER 2 GEOLOGY	8
INTRODUCTION	8
PREVIOUS WORK	8
PREVIOUS GEOPHYSICAL SURVEYS	9
GEOLOGY OF THE HOBART AREA	12
<i>STRATIGRAPHY</i>	
LOWER PARMEENER SUPER-GROUP	14
UPPER PARMEENER SUPER-GROUP	14
TERTIARY	18
QUATERNARY	20
<i>IGNEOUS ROCKS</i>	
JURASSIC DOLERITE	22
TERTIARY BASALT	24
STRUCTURE AND STRUCTURAL HISTORY	26
PETROPHYSICAL PROPERTIES	26
<i>MAGNETIC PROPERTIES</i>	27
<i>ACOUSTIC PROPERTIES</i>	28
CHAPTER 3 MAGNETIC SURVEY	30
FIELD WORK	30
SPACE WEATHER	33
DATA PROCESSING	35
HEADING TEST	43
CHAPTER 4 MAGNETIC MODELING	50
INTRODUCTION	50
SENSITIVITY TESTING	51
MODELING	57
CHAPTER 5 SEISMIC SURVEY	71
SEISMIC TERMS	72
ACOUSTIC TURBIDITY	77
THE BASALT THEORY	77
DISPROVING THE BASALT THEORY	79
THE EVIDENCE FOR SHALLOW GAS	79
<i>ACOUSTIC TURBIDITY</i>	82
<i>ENHANCED REFLECTIONS</i>	82
<i>ACOUSTIC BLANKING</i>	83
<i>PHASE REVERSALS</i>	83
<i>GAS SEEPS</i>	85
<i>VELOCITY PULLDOWN</i>	85
<i>INDIRECT EVIDENCE</i>	85

BIOGENIC METHANE PRODUCTION	92
SEDIMENT SAMPLING	96
OTHER SEISMIC FEATURES	100
CHAPTER 6 ACOUSTIC FINITE DIFFERENCING	106
CONCLUSIONS	113
CHAPTER 7 SEISMIC INTERPRETATION	114
CHAPTER 8 BATHYMETRIC SURVEY	157
CHAPTER 9 COMBINED GEOLOGICAL	
INTERPRETATION	162
CHAPTER 10 CONCLUSIONS AND FURTHER WORK	168
CONCLUSIONS	168
RECOMMENDATIONS FOR FURTHER WORK	168

REFERENCES

APPENDIX 1	LITERATURE REVIEW 'GLOBAL SEA LEVEL CHANGE OVER THE LAST 250,000 YEARS'
APPENDIX 2	SOURCE CODE FOR FORTRAN 77 PROGRAM 'HEADING' (WRITTEN BY D. GIBBONS)
APPENDIX 3	SOURCE CODE FOR FORTRAN 77 PROGRAM 'GEO2UTM' (WRITTEN BY D. GIBBONS)
APPENDIX 4	SOURCE CODE FOR QUICKBASIC PROGRAM 'LOCATE.BAS' (WRITTEN BY M. ROACH)
APPENDIX 5	SEISMIC UNIX SHELL SCRIPT FOR ACOUSTIC FINITE DIFFERENCING

List of Figures

Figure Number	Title/Description	Page
1.1	Overview map of study area (in the context of Tasmania)	2
1.2	Detailed map of study area	3
2.1	Traverse map and contours of the vertical component of magnetic intensity for the southern portion of a magnetic survey conducted in the Derwent Estuary in 1974/1975. Reproduced from Leaman (1975b).	10
2.2	Geological cross section from the Bowen Bridge alignment. Modified from Colhoun and Moon (1984)	12
2.3	Simplified geological map of the Hobart area	13
2.4	A photo of an exposure of Lower Parmeener Super-Group rocks at Opossum Bay (sparsely fossiliferous marine siltstone)	14
2.5	A map of the distribution of Lower Parmeener Super-Group rocks in the Hobart area	15
2.6	A photo of an exposure of Upper Parmeener Super-Group rocks at Second Bluff, Bellerive (current bedded sandstone)	16
2.7	A map of the distribution of Upper Parmeener Super-Group rocks in the Hobart area	17
2.8	A photo of Tertiary boulder beds exposed on the foreshore at Taroona	18
2.9	A map of the distribution of Tertiary sediments and sedimentary rocks in the Hobart area	19
2.10	A photo of Pleistocene marine sediments exposed at Arm End, South Arm	20
2.11	A map of the distribution of Quaternary sediments in the Hobart area	21
2.12	A photo of a thermal contact between a dolerite sill and Lower Parmeener Super-Group rocks near Blackmans Bay	22
2.13	A map of the distribution of Jurassic Dolerite in the Hobart area	23
2.14	A photo of a Tertiary basalt lava flow overlying a tuffaceous deposit exposed at Sandy Bay	24
2.15	A map of the distribution of Cenozoic volcanic rocks (i.e. Tertiary basalts) in the Hobart area	25
3.1.1	Photo of the FMV Nubeena, a TAFI research vessel. Taken near Electrona in North West Bay	30
3.1.2	Photo of the FMV Poolta, a TAFI research vessel. Taken near Electrona in North West Bay	31
3.2	A map of magnetic survey lines for 2000 and 2001 used for gridding (i.e. not all of the survey lines – some were removed prior to gridding. See also figure 3.9)	32
3.3	Chart of variation in horizontal magnetic intensity measured by the Hobart IPS gradiometer for 4 days in March 2001, demonstrating the magnetic effects of a magnetic storm	34
3.5	Chart of the G856 base station record for day 2 of the magnetic survey, 2001 (i.e. 21 st of March 2001)	35
3.6	Profile of magnetic intensity on line 5400 from the 2001 magnetic survey, showing drop outs	36
3.7	Profile of magnetic intensity on line 5400 after drop out editing	37
3.8	Profiles of magnetic intensity (after drop out editing) for all profiles used for gridding	38
3.9	All survey lines for the 2001 and 2000 magnetic surveys	39
3.10	False colour image of total magnetic intensity (TMI) grid	40
3.11	False colour image of total magnetic intensity grid from regional dataset for comparison to new data	41
3.12	Contour map of TMI, generated from gridded survey data	42
3.13	Schematic image of the magnetic response of a sphere of susceptible material, used to illustrate the effect of boat heading on magnetic measurements	43
3.14	Heading test data (raw) plotted as a function of time. Field and base station records shown	45

3.15	<i>Diurnally corrected heading test data and northings from GPS log as a function of time, illustrating low resolution of non-differentially corrected GPS position data</i>	46
3.16	<i>Observed and calculated heading test data. Calculated data used to apply corrections</i>	47
3.17	<i>Comparison of magnetic data from 2000 and 2001 surveys – selected points from line intersections</i>	49
4.1.1	<i>Sensitivity testing example chart 1</i>	51
4.1.2	<i>Sensitivity testing example chart 2</i>	52
4.1.3	<i>Sensitivity testing results chart 1</i>	53
4.1.4	<i>Sensitivity testing results chart 2</i>	53
4.1.5	<i>Potent model for sensitivity testing number 1</i>	54
4.1.6	<i>Potent model for sensitivity testing number 2</i>	55
4.1.7	<i>Potent model for sensitivity testing number 3</i>	55
4.1.8	<i>Potent model for sensitivity testing number 4</i>	56
4.2	<i>Traverse 1 model results</i>	58
4.3	<i>Traverse 2 model results</i>	59
4.4	<i>Traverse 3 model results</i>	60
4.5	<i>Traverse 4 model results</i>	61
4.6	<i>Traverse 5 model results</i>	62
4.7	<i>Traverse 6 model results</i>	63
4.8	<i>Traverse 8 model results</i>	64
4.9	<i>Traverse 9 model results</i>	65
4.10	<i>Traverse 10 model results</i>	66
4.11	<i>Traverse 11 model results</i>	67
4.12	<i>Traverse 12 model results</i>	68
4.13	<i>Traverse 14 model results</i>	69
4.14	<i>Traverse location map (for Potent models)</i>	70
5.1	<i>Photo of the boomer seismic source catamaran (on land)</i>	72
5.2	<i>Photo of the seismic receiver array (eel) in the water</i>	73
5.3	<i>Photo of the electrostatic printer used to output the seismic profiles</i>	74
5.4	<i>Photo of the FMV Mallanna (the vessel used for the seismic survey)</i>	75
5.5	<i>The two boats used for the seismic survey at Bridgewater. Two boats were used because of the shallow water depths.</i>	75
5.6	<i>Map of the seismic trackpaths, for 2000 and 2001</i>	76
5.7	<i>Calculated magnetic response of a thin sheet of basalt</i>	78
5.8	<i>Example of a 'blanket' of acoustic turbidity from Taylor (1992)</i>	80
5.9	<i>Map of the distribution of acoustic turbidity in the Derwent Estuary as defined from the seismic reflection profiles</i>	81
5.10	<i>Example 1 of a possible phase reversal on one of the seismic reflection profiles</i>	84
5.11	<i>Example 2 of a possible phase reversal on a seismic reflection profile</i>	84
5.12	<i>Example of probable gas seepage and velocity pulldown</i>	86
5.13	<i>Example of a pockmark from the Derwent Estuary</i>	88
5.14	<i>Example of a pockmark from the literature (Taylor, 1992)</i>	88
5.15	<i>Map of water column disturbances defined from the seismic reflection profiles</i>	90
5.16	<i>Schematic of possible chemical and biological boundaries and conditions necessary for the bacterial production of methane</i>	93
5.17	<i>Map of the distribution of calcium carbonate in the shallow sediments of the Derwent Estuary (provided by Dr. Peter Harris)</i>	95
5.18	<i>Photo of the 'Craic' corer owned by TAFI and used for shallow sediment sampling</i>	97
5.19	<i>Photo of borosilicate glass sample bottles used for the collection of wet sediment samples</i>	98
5.20	<i>Map of the location of sediment samples, coded according to measured methane concentration (normalised by sample mass)</i>	99
5.21	<i>Schematic of some seismic energy travelpaths – primary reflections</i>	100
5.22	<i>Schematic of some seismic energy travelpaths – simple multiples</i>	100
5.23	<i>Example of seafloor multiples</i>	101

5.24	<i>Schematic of some seismic energy travelpaths – complex multiples</i>	102
5.25	<i>Example 1 of multiple reflections from the Derwent Estuary seismic profiles</i>	103
5.26	<i>Example 2 of multiple reflections from the Derwent Estuary seismic profiles</i>	104
5.27	<i>Example of how a multiple reflection can interfere with the interpretation of primary reflections</i>	105
6.1	<i>The seismic profile taken alongside the southern side of the Tasman Bridge</i>	106
6.2	<i>The input velocity model used for acoustic finite difference (AFD) modeling</i>	108
6.3	<i>High frequency model output (i.e. a 'pseudo-boomer' record) from the AFD modeling</i>	109
6.4	<i>Moderate frequency model output from the AFD modeling</i>	110
6.5	<i>Low frequency model output from the AFD modeling</i>	111
6.5	<i>Low frequency 'pseudo-boomer' record calculated by acoustic finite differencing</i>	
7.1	<i>Trackpaths map for 'long' seismic lines (i.e. lines 3,5,7,21,22,23,16 and 17)</i>	115
7.2	<i>Trackpaths map 2 for 'short' seismic lines (i.e. lines 24 to 34 inclusive)</i>	116
7.3.1	<i>Line 3 raw seismic profile</i>	119
7.3.2	<i>Line 3, interpretation</i>	120
7.4.1	<i>Line 23, raw seismic profile</i>	121
7.4.2	<i>Line 23, interpretation</i>	122
7.5.1	<i>Line 22, raw seismic profile</i>	123
7.5.2	<i>Line 22, interpretation</i>	124
7.6.1	<i>Line 5, raw seismic profile</i>	125
7.6.2	<i>Line 5, interpretation</i>	126
7.7.1	<i>Line 16, raw seismic profile</i>	127
7.7.2	<i>Line 16, interpretation</i>	128
7.8.1	<i>Line 17, raw seismic profile</i>	129
7.8.2	<i>Line 17, interpretation</i>	130
7.9.1	<i>Line 21, raw seismic profile</i>	131
7.9.2	<i>Line 21, interpretation</i>	132
7.10.1	<i>Line 7, raw seismic profile</i>	133
7.10.2	<i>Line 7, interpretation</i>	134
7.11.1	<i>Line 24, raw seismic profile</i>	135
7.11.2	<i>Line 24, interpretation</i>	136
7.12.1	<i>Line 25, raw seismic profile</i>	137
7.12.2	<i>Line 25, interpretation</i>	138
7.13.1	<i>Line 26, raw seismic profile</i>	139
7.13.2	<i>Line 26, interpretation</i>	140
7.14.1	<i>Line 27, raw seismic profile</i>	141
7.14.2	<i>Line 27, interpretation</i>	142
7.15.1	<i>Line 28, raw seismic profile</i>	143
7.15.2	<i>Line 28, interpretation</i>	144
7.16.1	<i>Line 29, raw seismic profile</i>	145
7.16.2	<i>Line 29, interpretation</i>	146
7.17.1	<i>Line 30, raw seismic profile</i>	147
7.17.2	<i>Line 30, interpretation</i>	148
7.18.1	<i>Line 31, raw seismic profile</i>	149
7.18.2	<i>Line 31, interpretation</i>	150
7.19.1	<i>Line 32, raw seismic profile</i>	151
7.19.2	<i>Line 32, interpretation</i>	152
7.20.1	<i>Line 33, raw seismic profile</i>	153
7.20.2	<i>Line 33, interpretation</i>	154
7.21.1	<i>Line 34, raw seismic profile</i>	155
7.21.2	<i>Line 34, interpretation</i>	156
8.1	<i>False-colour image of bathymetry, generated from gridded data</i>	160
8.2	<i>Contours of bathymetry, generated from gridded data</i>	161
9.1	<i>Combined geological interpretation map</i>	165
9.2	<i>Image of gridded magnetic data, reduced to the pole. Used for qualitative interpretation</i>	166
9.3	<i>Image of first vertical derivative of reduced to pole magnetic data. Used for qualitative interpretation</i>	167

List of Tables

Table Number	Title/Description	Page
1	<i>List of sonic velocity ranges for common geological materials found in the Hobart area</i>	29
2	<i>Results of headspace gas analysis</i>	98